THE INFLUENCE OF ALCOHOL AND ALCOHOLIC DRINKS UPON THE CHEMICAL PROCESSES OF DIGESTION.[1]

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ACTION OF WINES.

IN considering the action of wines on gastric digestion it is to be remembered that we have to deal with a class of beverages which naturally contain far less alcohol than the liquors already discussed. The prominence which they have as accessories to food, however, and the relatively larger quantities in which they are consumed lend special importance from a physiological standpoint to a study of their action. Further, the greater complexity of wines in chemical composition naturally introduces a variety of factors, aside from the alcohol, which necessarily merit some consideration. It is likewise to be remembered that while wines are supposed to consist simply of pure grape-juice fermented and clarified, there is a large manufacture of artificial wines, both in Europe and in this country, in which "raisins, cider, sugar, alcohol, glycerin, tartaric acid, cream of tartar, coloring-matter, wine-flavors, and water" are the principal substances used.[1]

With special reference to the content of alcohol we may divide wines into the two classes of heavy and light—*i. e.*, those which contain a comparatively large percentage of alcohol, as sherry and port, and those which contain a smaller amount of alcohol, such as clarets and hocks. With reference to the many grades of California wines which are being so widely used at present in this country, we may refer to a recent report on their chemical composition and characteristics by Dr. King.[2]

Sherry.

Our experiments were commenced with a brand of sherry sold as "Amontillado Sherry," at 75 cents per quart. Its composition was found to be as follows:

Specific gravity	0.997 (at 17.5° C.).
Alcohol by volume	20.75–21.75 per cent.
Solid residue at 110° C. . . .	4.7338 grams per 100 c.c.
Ash	0.4154 gram " "
Reaction acid.	

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[1] See report by Dr. Englehardt in the Second Annual Report of the State Board of Health of New York, p. 619.

[2] "Some Characteristics of California Wines," by W. H. King, of the Chemical Laboratory of the U. S. Department of Agriculture. Journal of Amer. Chem. Soc., vol. xvi. p. 597.

Experiment 49.

Conditions:

Proteid = cooked beef proteids[1] (10 grams).
10 grams beef contain 4.3262 grams dry proteid.
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 7⅛ hours at 38°–40° C.

Sherry.	Undigested beef.	Proteid digested.	Relative proteolytic action.
0 per cent.	1.9810 grams.	54.3 per cent.	100.0
1 "	2.0839 "	51.9 "	95.5
3 "	2.0995 "	51.5 "	94.8
6 "	2.1102 "	51.3 "	94.4

Experiment 50.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2¾ hours at 38°–40° C.

Sherry.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3646 gram.	81.8 per cent.	100.0
1 "	0.3555 "	82.3 "	100.6
3 "	0.4075 "	79.7 "	97.4
6 "	0.4213 "	79.0 "	96.5

Experiment 51.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c.c. albumin solution contain 1.0522 grams dry albumin.
0.0024 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 5¾ hours at 38°–40° C.

Sherry.	Undigested albumin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4547 gram.	56.8 per cent.	100.0
1 "	0.5072 "	51.8 "	91.1
3 "	0.5101 "	51.6 "	90.8
5 "	0.5806 "	44.9 "	79.0
7 "	0.5916 "	43.8 "	77.1
Sherry residue.[2]			
1 per cent.	0.4912 "	53.4 "	94.0
7 "	0.5482 "	47.9 "	84.3

Experiment 52.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c.c. albumin solution contain 1.1948 grams dry albumin.
0.0024 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion $5\frac{7}{12}$ hours at 38°–40° C.

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[1] Washed free from all soluble matters and freed from fat.

[2] The residue left on evaporation of the sherry. This was then dissolved in water and introduced into the digestive mixtures, the percentages referred to being the amount of residue contained in 1 per cent. and 7 per cent. of the original sherry, respectively.

influence of alcoholic liquors on peptic digestion, found that the light white and red French wines retarded digestion far more than corresponding quantities of alcohol. Similar results were obtained with the stronger Hungarian wines (Ruster and Tokayer). Especially unfavorable was the action of Marsala wine. Buchner attributed these results to the presence of the "*bouquet stoffe.*" It is evident, however, from our results that with sherry regard must be had to the residue or solid matter contained in the wine. This, as our analysis shows, is present in the wine to the extent of approximately 4.75 per cent., the greater proportion of which is organic matter. Further, it is evident that this solid matter, when free from the alcohol of the wine, has by itself a distinct influence on peptic digestion. So far as our experiments show, small amounts of this solid matter retard peptic digestion more than larger quantities. Indeed, in one case the solid matter equivalent to 6 per cent. of sherry increased the digestive action of the artificial gastric juice quite appreciably. Evidently there are various factors of unknown nature in this residue which exert an influence, not always constant, upon the rate of digestive proteolysis by pepsin-hydrochloric acid.

The following experiments throw some additional light upon this subject:

Experiment 55.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2¼ hours at 38°–40° C.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2027 gram.	89.9 per cent.	100.0
5 " sherry	0.2340 "	88.3 "	98.2
5 " " residue	0.2627 "	86.9 "	96.6
5 " absol. alcoh.	0.2619 "	87.0 "	96.7

Experiment 56.

Conditions the same as in the preceding experiment, except that the mixtures were warmed at 38°–40° C. for $1\frac{7}{12}$ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3247 gram.	83.8 per cent.	100.0
5 " absol. alcoh.	0.3554 "	82.3 "	98.2
10 " sherry	0.4785 "	76.1 "	90.8
10 " " distillate[1]	0.2855 "	85 8 "	102.3
10 " " residue	0.4453 "	77.8 "	92 8

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[1] Being the distillate from this amount of sherry and containing obviously all of the alcohol together with the other volatile substances present therein.

It is thus evident that so far as the alcohol and other volatile substances present in sherry are concerned, the amount introduced into an artificial gastric juice with 10 per cent. of sherry (*i. e.*, 10 c.c.) tends to increase quite distinctly the rate of digestion. Hence, the substance or substances which give the bouquet to this wine are probably not the cause of the retardation in digestive action, but this is to be traced directly and solely to the substance or substances which make up the solid matter of the wine. Obviously, however, if sherry be mixed with gastric juice in such quantity as to introduce 5, 10, or 15 per cent. of absolute alcohol the latter will produce its ordinary retardation of proteolytic action, although doubtless lessened somewhat by the bouquet or other volatile material which apparently stimulates rather than retards peptic digestion.

Our results are thus more or less in accord with the results obtained by Sir William Roberts,[1] who in writing of the effects of sherry and port on gastric digestion says, "It is evident that the retarding effects of sherry and port considerably exceed what is due to the alcohol contained in them. The table shows that when the digesting mixture contained 40 per cent. of either wine the action of the ferment was brought almost to a standstill. These wines are estimated to contain about 20 per cent. of absolute alcohol (or 40 per cent. of proof-spirit); therefore, 40 per cent. of these wines is only equivalent in alcoholic strength to 16 per cent. of proof-spirit—and this proportion of alcohol retards digestion only slightly. Even in the proportion of 20 per cent., sherry trebled the time in which digestion was completed. There must, therefore, be in these wines some retarding agent besides alcohol."

We may quote Dr. Roberts still further in this connection, since his statements express so clearly our own conclusions based upon the results we have obtained: "As used dietetically, sherry must figure as having frequently an important retarding effect on peptic digestion. This wine is used with dinner by some persons very freely. Half a pint of sherry is no unusual allowance, and this in a total gastric charge of two pounds amounts to about 25 per cent., which the table shows to be a highly inhibitory proportion. In the more common practice of taking two or three wineglasses of sherry with dinner, we see probably a double action —a stimulating action on the secretion of gastric juice and on the muscular contractions of the stomach, and a slight retarding effect on the speed of the chemical process, especially in its early stages. In smaller proportions—a wineglass or so—sherry would act as a pure stimulant to digestion." On the purely chemical process of gastric digestion, however, we should be inclined, from the results of our own experiments, to insist that even small amounts of sherry may exert a slight inhibitory action. As to the cause of the retarding action of sherry, Roberts considers it due largely to the volatile constituents of the wine other than the alcohol, while our experiments would lead us to believe that it is attributable mainly to the character of the solid matter contained therein.

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[1] Digestion and Diet: "Effect of Food Accessories on Peptic Digestion," London, 1891, p. 134.

Claret.

Our experiments with claret were conducted solely with a California wine of ordinary grade, known as "Chateau Roland, Bordeaux," sold at 30 cents a quart. Its composition was as follows:

Specific gravity	1.000 (at 20° C.).
Alcohol by volume	9.75–10.0 per cent.
Solid residue at 110° C. . . .	3.3056 grams per 100 c.c.
Ash	0.6336 gram " "
Reaction strongly acid.	

That this was a typical sample of a California wine of the claret type, at least so far as the content of alcohol is concerned, is indicated by the fact that King[1] states in his paper on the "Characteristics of California Wines" that California clarets contain 9.16–11.23 per cent. of alcohol.

Experiment 57.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion $2\frac{5}{12}$ hours at 38°–40° C.

Claret.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3401 gram.	83.0 per cent.	100.0
1 "	0.3252 "	83.8 "	100.9
3 "	0.3965 "	80.2 "	96.6
6 "	0.3732 "	81.4 "	98.0

Experiment 58.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c c. albumin solution contain 1.347 grams dry albumin.
0.04 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 7 hours at 38°–40° C.

Claret.	Undigested albumin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5800 gram.	57.0 per cent.	100.0
1 "	0.5313 "	60.6 "	106.3
3 "	0.5899 "	56.3 "	98.7
6 "	0.5892 "	56.3 "	98.7
Claret residue.[2]			
1 per cent.	0.5865 "	56.5 "	99.1
3 "	0.5253 "	61.0 "	107.0
6 "	0.5903 "	56.2 "	98.5

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[1] Loc. cit.

[2] The residue left on evaporation of the claret. The several percentages refer to the original claret, *i.e.*, the 1 per cent. claret residue being the residue from 1 per cent. of claret.

Experiment 59.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c.c. albumin solution contain 1.1948 grams dry albumin.
0.0024 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion $5\frac{1}{12}$ hours at 38°–40° C.

Claret.	Undigested albumin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.6808 gram.	43.2 per cent.	100.0
1 “	0.6801 “	43.2 “	100.0
3 “	0.6950 “	41.9 “	96.9
5 “	0.7258 “	39.3 “	90.9
7 “	0.7238 “	39.5 “	91.2
Claret residue.			
1 per cent.	0.6546 “	45.3 “	104.8
3 “	0.6785 “	43.3 “	100.2
7 “	0.6847 “	42.7 “	98.8

Experiment 60.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c.c. albumin solution contain 1.347 grams dry albumin.
0.0024 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion $6\frac{1}{4}$ hours at 38°–40° C.

Claret.	Undigested albumin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.7659 gram.	43.2 per cent.	100.0
1 “	0.7839 “	41.9 “	96.9
3 “	0.7980 “	40.8 “	94.4
6 “	0.8161 “	39.5 “	91.2
Claret residue.			
1 per cent.	0.7589 “	43.7 “	101.1
6 “	0.7644 “	43.2 “	100.0

Experiment 61.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion $2\frac{1}{4}$ hours at 38°–40° C.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2013 gram.	90.0 per cent.	100.0
5 “ absol. alcoh.	0.2601 “	87.0 “	96.6
5 “ claret	0.2560 “	87.2 “	96.8

Experiment 62.

Conditions exactly the same as in the preceding experiment.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.1759 gram.	91.3 per cent.	100.0
5 “ absol. alcoh.	0.2145 “	89.3 “	97.8
5 “ claret residue	0.2214 “	89.0 “	97.4

From a careful scrutiny of these results several conclusions are obvious: First, the presence of small amounts of claret, say 1 per cent., in a digestive mixture tends to increase rather than to decrease digestive action. Large amounts of claret have a distinct inhibitory action on pepsin-proteolysis, which, however, is not anywhere near so pronounced as with sherry. To be sure, the content of alcohol in the claret is only half that of the sherry, but even 6 per cent. of claret is equal to only 0.6 per cent. of absolute alcohol. Yet the retardation produced by the presence of 5 per cent. of claret is about equivalent to that caused by 5 per cent. of absolute alcohol. Consequently, the retardation in gastric digestion witnessed in the presence of the above percentages of claret is hardly to be attributed to the contained alcohol.

With the solid matter present in claret our results are not strictly concordant; thus, some of our experiments tend to show that the solid matter present in this wine has a direct stimulating effect, while in other experiments the retardation produced by the solid matter of the wine is exactly equal to that of the wine itself. We have not been able to come to any satisfactory conclusion on this point, the only plausible suggestion that we have to offer being that possibly the difficulty lies in the variable character of the coloring and other matters present in the wine. In any event, the alcohol present in this wine is answerable for its action on gastric digestion only to a very limited extent. Again, we find our results in close accord with those obtained by Roberts. Thus, this investigator states that the effect of both claret and hock is out of all proportion to the alcohol contained in them: "These wines are estimated to contain from 10 to 20 per cent. of absolute alcohol, so that, however freely they might be used dietetically, the amount of alcohol so introduced, even if they were used up to 80 per cent. of the total contents of the stomach, would scarcely produce an appreciable effect on peptic action. We must, therefore, again here recognize the presence of some other retarding agent besides alcohol.

"If we consider the copious proportions in which hock and claret are used dietetically, it becomes evident that their retarding effect on peptic digestion is often brought into play. A pint of claret or hock is a common allowance with dinner for robust eaters—and such a proportion as the table shows would not be without considerable effect. . . . On the other hand, the more sparing use of these wines, a glass or two, with dinner or luncheon would evidently not produce any appreciable retardation of peptic action, but would, like corresponding doses of sherry, act as pure stimulants. In both these instances, as in some others, it seems to be indicated that by adjusting the quantities we may elicit diverse effects. With large quantities we may obtain retardation; with small quantities we may obtain acceleration of gastric digestion."[1] With these statements our results are mainly in accord.

White Wine of the Rhenish Type.

In our study of this kind of wine we employed a California wine sold under the name of "Hochheimer" at 35 cents per quart. Our analysis of the brand employed gave the following results:

Specific gravity	0.997 (at 17° C.).
Alcohol by volume	11.0 per cent.
Solid residue at 110° C.	1.8436 grams per 100 c.c.
Ash	0.2236 gram " "
Reaction acid.	

The wines of this type, as King states, are characterized by a content of alcohol varying from 8.45 to 11.67 per cent., and with an acidity equal to 0.50 to 0.65 per cent. of tartaric acid.

Experiment 63.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 1½ hours at 38°–40° C.

White wine.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2829 gram.	85.9 per cent.	100.0
1 "	0.2716 "	86.5 "	100.6
3 "	0.3122 "	84.4 "	98.2
6 "	0.3464 "	82.7 "	96.2

Experiment 64.

Conditions same as above, but the period of digestion 2½ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2013 gram.	90.0 per cent.	100.0
5 " wine	0.2439 "	87.9 "	97.6
5 " absol. alcoh.	0.2601 "	87.0 "	96.6

Experiment 65.

Conditions the same as in the preceding experiment.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.1759 gram.	91.3 per cent.	100.0
5 " absol. alcoh.	0.2145 "	89 3 "	97.8
5 " wine residue	0.2158 "	89.3 "	97.8

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[1] Roberts: Digestion and Diet, p. 136.

Experiment 66.

Conditions same as above, but the period of digestion 1¾ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2032 gram.	89.9 per cent.	100.0
5 " absol. alcoh.	0.2317 "	88.5 "	98.4
10 " wine	0.2531 "	87.4 "	97.2
10 " " distillate[1]	0.2063 "	89.7 "	99.7
10 " " residue	0.2810 "	86.0 "	95.6

From these results it is obvious that essentially the same conclusions can be drawn with regard to this white wine as have been applied to claret. A small quantity, such as 1 per cent., has no retarding action on pepsin-proteolysis, but tends rather to increase the rate of digestion. Larger amounts of the wine, say 10 per cent., have a small retarding effect, which is due almost wholly to the solid matter present in the wine rather than to the alcohol or other volatile matter. Thus, the distillate (Experiment 66) corresponding to 10 per cent. of the original wine had almost no retarding action on gastric digestion, while the residue from the same amount of wine caused a retardation even greater than that produced by the wine itself. At the same time, it is to be noticed that the white wine is far less active in retarding pepsin-proteolysis than the red wine. This difference in intensity of action depends probably upon the character of the solid matter present in the wine, or possibly upon the amount of such matter; the claret containing 3.3056 grams of solid matter per 100 c.c., while the white wine contained only 1.8436 grams per 100 c.c. Doubtless, however, differences in the methods of treating the grape in the manufacture of the wine, the processes of plastering and mixing, as well as the variations the artistic mixer of wines may introduce, all have an influence in determining the character of this solid residue, which seems far more potent than the alcohol in acting upon the digestive process.

Hence, we may conclude that wines as a class, taken in small amount, have little or no deleterious influence upon the chemical processes of gastric digestion. In small amounts they may even increase somewhat the rate of digestive action owing to the alcohol, and perhaps other substances, contained in them. In larger quantities they have more or less of a retarding effect upon gastric digestion; an effect which is dependent rather upon the character and amount of the solid matter present in the fluid than upon the contained alcohol, bouquet-flavoring, or other volatile material. Indeed, wines differ most markedly from liquors of the brandy and whiskey type, in that their action upon gastric digestion is not at all proportional to their content of alcohol. As we have seen, whiskeys, brandies, etc., owe their action upon pepsin-proteolysis almost wholly to the contained alcohol, while in wines, say with 10 per cent. of alcohol, the alcohol is of minor importance so far as the influence of the fluid upon the solvent or digestive power of the gastric juice is concerned.

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[1] Being the volatile matter, alcohol, etc., obtainable from an amount of wine equivalent to 10 per cent. of the original hochheimer.

DIRECT COMPARISON OF THE ACTION OF SOME OF THE FOREGOING LIQUORS.

The comparative action of the alcoholic fluids thus far studied has perhaps been made sufficiently clear, but inasmuch as the conditions under which proteolysis occurs have such an important bearing upon the rate of digestion, we have deemed it wise to make an experiment with representatives of the different liquors in which all of the attendant conditions should be identical. The results are shown in the following experiment:

Experiment 67.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2¼ hours at 38°–40° C.

Fluid used, 5 per cent.	Alcoholic strength.[1]	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0	0	0.2013 gram.	90.0 per cent.	100.0
Absol. alcoh.	99.5 per cent.	0.2601 "	87.0 "	96.6
Rum	51.0 "	0.2304 "	88.5 "	98.3
Whiskey	50.5 "	0.2312 "	88.5 "	98.3
Brandy	47.5 "	0.2251 "	88.8 "	98.7
Sherry	21.0 "	0.3041 "	84.8 "	94.2
Hochheimer	11 0 "	0.2439 "	87.9 "	97.6
Claret	10.0 "	0.2560 "	87.2 "	96.8

These results, obtained under exactly similar conditions, are suggestive in that they show so clearly the relative retarding action of these several alcoholic fluids. Sherry, with its high content of solid matter (about 4.75 per cent.), shows the greatest retarding action, while claret and absolute alcohol come next, followed by the hochheimer. Rum, whiskey, and brandy, with the highest content of alcohol, produce the least effect, in harmony with the preceding experiments, so that we again have evidence of the greater retarding effect of the solid matters contained in wines. Alcohol plainly reduces the rate of pepsin-proteolysis, but 5 per cent. of pure absolute alcohol has no greater retarding action than the same percentage of claret with only one-tenth as much absolute alcohol. Again, rum, whiskey, and brandy cause approximately only half the retardation that the same percentage of claret will produce, although the latter contains only one-fifth as much absolute alcohol.

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[1] Being the content of alcohol in the fluid added.

ACTION OF MALT LIQUORS.

Under this term are included a large variety of beverages, such as beers, ales, porter, stout, etc., all of which are supposed to contain only a comparatively small amount of alcohol, with a relatively large amount of extractive matter. "The composition of malt liquors varies greatly according to the materials used, the method of brewing, the season, and the use for which it is intended. . . . The chemical composition is very complex, the principal constituents being alcohol, various sugars, and carbohydrates, nitrogenous matter, carbonic, acetic, succinic, lactic, malic, and tannic acids, bitter and resinous extractive materials from the hops, glycerin, and various mineral constituents, consisting mainly of phosphates of the alkalies and alkali earths."[1]

The following table shows the maximum and minimum content of alcohol, extract, and ash in 476 samples obtained in American markets:[2]

Kind.	Maximum.			Minimum.		
	Alcohol by weight.	Extract.	Ash.	Alcohol by weight.	Extract.	Ash.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Lager	7.061	9.647	0.412	0.677	3.655	0.172
Ale	8.994	9.501	0.552	2.410	2.703	0.197
Porter	6.695	11.783	0.557	1.671	2.843	0.170
Weiss	3.179	4.143	0.486	0.755	1.277	0.069

A recent examination[3] of Munich beer made in the analytical laboratory of the London *Lancet*, with which the composition of English beer has been contrasted, gave the following results:

	Munich beer.	English beers.	
	Löwenbrau.	Mild.	Bitter.
Alcohol by weight	3.55 per cent.	6.78 per cent.	5.44 per cent.
Alcohol by volume	4.45 "	8.45 "	6.78 "
Equal to proof-spirit	7.80 "	14.81 "	11.89 "
Total malt extractives	7.09 "	6.74 "	5.42 "
Mineral matters	0.36 "	0.43 "	0.24 "
Albuminous matters	0.57 "	0.26 "	0.16 "
Maltose and dextrin	6.15 "	5.77 "	4.22 "

Toledo Lager Beer.

A partial analysis of this beer gave us the following results:

Specific gravity	1.019 (at 17.5° C.).
Alcohol by volume	2.75 per cent.
Extract	5.9856 grams per 100 c.c.
Ash	0.1820 gram " "

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[1] Bulletin 13, part 3, p. 275, U. S. Department of Agriculture, Division of Chemistry.

[2] Ibid., p. 279.

[3] London Lancet, February 16, 1895.

Experiment 68.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c.c. of the albumin solution contain 1.3395 grams dry albumin.
0.006 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 7 hours at 38°–40° C.

Beer.	Undigested albumin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4121 gram.	69.3 per cent.	100.0
1 "	0.4110 "	69.4 "	100.1
3 "	0.4347 "	67.6 "	97.5
5 "	0.4314 "	67.8 "	97.8
7 "	0.5183 "	61.4 "	88.6
Beer residue.			
1 per cent.	0.4042 "	69.9 "	100.9
7 "	0.4546 "	66.1 "	95.3

Milwaukee Bock Beer.

This sample of beer, "Milwaukee Lager Beer, Pabst's Bock," had the following composition:

Specific gravity	1.017 (at 17.5° C.).
Alcohol by volume	2.5 per cent.
Extract	2.6479 grams per 100 c.c.
Ash	0.1462 gram " "

Experiment 69.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 1½ hours at 38°–40° C.

Beer.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2829 gram.	85.9 per cent.	100.0
1 "	0.2738 "	86.4 "	100.5
3 "	0.3085 "	84.6 "	98.4
6 "	0.3183 "	84.1 "	97.9
Beer residue.			
6 per cent.	0.3079 "	84.6 "	98.4

New Haven Lager Beer.

This beer gave on analysis the following results:

Specific gravity	1.026 (at 18° C.).
Alcohol by volume	1 5 per cent.
Extract	7.1236 grams per 100 c.c.
Ash	0.2192 gram " "

Experiment 70.

Conditions:

Proteid = cooked and washed beef proteid (10 grams moist).
10 grams beef proteid contain 4.3262 grams dry proteid.
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 7⅛ hours at 38°–40° C.

Beer.	Undigested proteid.	Proteid digested.	Relative proteolytic action.
0 per cent.	1.9810 grams.	54.3 per cent.	100.0
1 "	1.9513 "	54.9 "	101.1
3 "	2.0189 "	53.4 "	98.3

Experiment 71.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2¾ hours at 38°–40° C.

Beer.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3646 gram.	81.8 per cent.	100.0
3 "	0.3591 "	82.1 "	100.3
6 "	0.3961 "	80.2 "	98.0

Experiment 72.

Conditions the same as in the preceding experiment, except that the period of digestion was $2\frac{1}{12}$ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4630 gram.	76.9 per cent.	100.0
2 " absol. alcoh.	0.4583 "	77.1 "	100.2
10 " beer	0.5218 "	74.0 "	96.2
10 " " residue	0.5134 "	74.4 "	96.7
10 " " distillate	0.4127 "	79.4 "	103.2

From these experiments with beer containing a low content of alcohol, it is seen that the tendency is toward a slight retardation of proteolysis. The extent of retardation with a given percentage of beer is dependent, however, upon the digestive strength of the gastric juice. Where digestive action is fairly strong, retardation with, say, 10 per cent. of beer is very slight, and if we are to trust the result of Experiment 72 the inhibitory action is to be connected mainly with the extractive matters present in the beer rather than with the alcohol. Indeed, the amount of alcohol in these beers is altogether too small to have any appreciable retarding action upon the chemical processes of gastric digestion unless the beverage is consumed in very large quantity.

Especially noticeable is the constant, though slight, stimulation of proteolysis caused by a small percentage of beer.

According to Roberts, beer, when "well up," is distinctly more favorable to quick digestion than the same beer when "flat." This effect, he adds, is probably due to the mechanical effect of the escaping gas in stirring up the mixture.

ALE.

The ale used in the following experiments was "Burton Pale Ale," Bass & Co.'s Extra. A partial analysis of one sample gave the following results:

Specific gravity	1.014 (at 20° C.).
Alcohol by volume	4.0 per cent.
Extract	4.4254 grams per 100 c.c.
Ash	0.3530 gram " "

In another sample the content of alcohol was 5.25 per cent.

Experiment 73.

Conditions:

Proteid = fluid egg-albumin (15 c.c.).
15 c.c. albumin solution contain 1.347 grams dry albumin.
0.0024 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion $6\frac{5}{12}$ hours at 38°–40° C.

Ale.	Undigested albumin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.7861 gram.	41.7 per cent.	100.0
1 "	0.7908 "	41.3 "	99.0
3 "	0.7826 "	41.9 "	100.3
5 "	0.8304 "	38.4 "	92.0
7 "	0.8496 "	37.0 "	88.7
Ale residue.			
1 per cent.	0.7498 "	44.0 "	105.5
7 "	0.8094 "	40.0 "	95.9

Experiment 74.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2½ hours at 38°–40° C.

Ale.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4263 gram.	78.7 per cent.	100.0
1 "	0.4528 "	77.4 "	98.3
3 "	0.4636 "	76.9 "	97.7
6 "	0.5031 "	74.9 "	95.1

Experiment 75.

Conditions same as in the preceding experiment, except that the period of digestion was 1¾ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5068 gram.	74.7 per cent.	100.0
2 " absol. alcoh.	0.4970 "	75.2 "	100.6
10 " ale	0.7218 "	64.0 "	85.6
10 " " distillate	0.5302 "	73 5 "	98.3
10 " " residue[1]	0.6988 "	65.1 "	87.1
10 " " "[2]	0.7060 "	64.7 "	86.6

The results are essentially of the same order as those obtained with beer, although the ale appears to have a somewhat greater retarding action than lager beer.

PORTER.

The porter used in our experiments was labelled "Feigenspan's," Newark, and had the following composition:

Specific gravity	1.011 (at 18.5° C.).
Alcohol by volume	3.75 per cent.
Extract	4.4470 grams per 100 c.c.
Ash	0.2586 gram " "

Experiment 76.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2$\frac{5}{12}$ hours at 38°–40° C.

Porter.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3401 gram.	83.0 per cent.	100.0
1 "	0.4038 "	79.9 "	96.2
3 "	0.4226 "	78.9 "	95.0
6 "	0.4335 "	78.4 "	94 4

Experiment 77.

Conditions the same as in the preceding experiment, except that the period of digestion was 2$\frac{1}{4}$ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3881 gram.	80.6 per cent.	100.0
4 " absol. alcoh.	0.4118 "	79.5 "	98.6
10 " porter	0.4208 "	79.0 "	98.0
10 " " distillate	0.3783 "	81.1 "	100.6
10 " " residue[3]	0.4480 "	77.6 "	96.2
10 " " "[4]	0.4447 "	77.8 "	96.5

Porter is thus seen to have about the same retarding action on pepsin-proteolysis as lager beer, although not showing the stimulation so characteristic of small quantities of this latter fluid. Further, such retardation as is produced is associated mainly with the presence of the extractives rather than with the volatile matters present in the fluid.

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[1] Made up so as to contain 4 per cent. of alcohol.

[2] Dissolved in water.

[3] Made up to contain 4 per cent. of alcohol.

[4] Dissolved in water.

STOUT.

The stout used was "Guiness's Dublin Stout," with the following composition:

Specific gravity	1.013.
Alcohol by volume	5.5 per cent.
Extract	5.4220 grams per 100 c.c.
Ash	0.3612 gram " "

Experiment 78.

Conditions:

Proteid = blood-fibrin (2 grams).
0.016 gram pepsin; 0.2 per cent. hydrochloric acid.
Period of digestion 2½ hours at 38°–40° C.

Stout.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4263 gram.	78.7 per cent.	100.0
1 "	0.4133 "	79.4 "	100.8
3 "	0.4440 "	77.8 "	98.8
6 "	0.4839 "	75.9 "	96.4

Experiment 79.

Conditions the same as in the preceding experiment, except that the period of digestion was 2 hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5315 gram.	73.5 per cent.	100.0
2 " absol. alcoh.	0.5390 "	73.1 "	99.4
10 " stout	0.6582 "	67.1 "	91.2
10 " " distillate	0.5317 "	73.5 "	100.0
10 " " residue[1]	0.6665 "	66.7 "	90.7
10 " " " [2]	0.6675 "	66.7 "	90.7

Here, again, we have essentially the same results as were obtained with lager beer and ale. With 10 per cent. of stout there is a distinct retardation of pepsin-proteolysis, perhaps even greater than with either of the other fluids of this class; a retardation, however, that is due almost wholly to the contained extractives rather than to the alcohol or other volatile matters. Thus, while the distillate from this liquor is entirely without action upon pepsin-proteolysis, the residue or extractive matter inhibits digestion to about the same extent as the beverage itself.

Taken collectively, our experiments with malt liquors tend to show that the retarding effect of these fluids is, as is the case with wines, altogether out of proportion to their content of alcohol. Containing, as a rule, not much more than 4 to 6 per cent. of alcohol, the latter, when consumed in the ordinary forms of malt liquors, can have very little influence upon the chemical processes of gastric digestion. When, however, these beverages are consumed very freely with the meals, so that the digesting mass in the stomach contains 50 or 60 per cent. of these fluids, one can easily see from the results reported that the retarding action upon the solvent or digestive power of the gastric juice must be very considerable, owing to the action of the extractives they contain. Taken in small quantities, on the other hand, these malt liquors are without any marked effect upon the proteolytic action of the gastric juice.

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[1] Made up to contain 4 per cent. of alcohol.

[2] Dissolved in water.

The inhibitory action of these fluids is to be compared with the inhibitory action of such beverages as tea and coffee, the retarding action of which is equally pronounced or even greater when the latter are consumed in large quantities. In this connection it seems no more than proper to add that the extractives or solid matters ordinarily present in malt liquors are not especially peculiar in possessing this retarding action upon pepsin-proteolysis. It is, indeed, a property shared by many substances, and does not in itself necessarily constitute an evil of any great magnitude unless the retardation is very pronounced and liable to be long continued. Then, indeed, it may become a serious evil, and one sufficient to condemn the substance which causes it.

COMPARATIVE ACTION OF SOME ALCOHOLIC LIQUORS ON PEPSIN-PROTEOLYSIS.

The following tables, the figures of which are taken from experiments already recorded, may serve to show the relative action of given percentages of the more common alcoholic liquors on the solvent power of the gastric juice, the results in each table having been obtained under exactly similar conditions:

Per cent. of liquor in each digestive mixture.	Relative proteolytic action.	
	Sherry.	Beer.
0 per cent.	100.0	100.0
1 "	95.5	101.1
3 "	94.8	98.3
	Sherry.	Beer.
0 per cent.	100.0	100.0
3 "	97.4	100.3
6 "	96.5	98.0
	Whiskey.	Brandy.
0 per cent.	100.0	100.0
1 "	100.3	100.6
3 "	100.0	99.7
6 "	98.4	99.8

Per cent. of liquor in each digestive mixture.	Relative proteolytic action.	
	Brandy.	Sherry.
0 per cent.	100.0	100.0
10 "	97.0	90.8
	Whiskey.	Hochheimer.
0 per cent.	100.0	100.0
10 "	99.1	97.2
	Claret.	Porter.
0 per cent.	100.0	100.0
1 "	100.9	96.2
3 "	96.6	95.0
6 "	98.0	94.4
	Stout.	Ale.
0 per cent.	100.0	100.0
1 "	100.8	98.3
3 "	98.8	97.7
6 "	96.4	95.1
	Bock-beer.	Hochheimer.
0 per cent.	100.0	100.0
1 "	100.5	100.6
3 "	98.4	98.2
6 "	97.9	96.2

Before leaving this phase of our subject it may be wise to emphasize again the exact scope of these experiments. It is to be remembered that the results here recorded are capable merely of throwing light upon the influence of the various alcoholic beverages on the digestive or solvent power of the gastric juice. They are not broadly applicable to a determination of the influence of the liquors in question on gastric digestion, since they afford no light as to the influence of these fluids upon the secretion of gastric juice, or upon the mechanical movements of the stomach, or upon the process of absorption. Hence, if we are to be governed by facts, we are not as yet ready to draw any broad generalizations as to the influence of alcoholic liquors upon gastric digestion. We must at present confine ourselves to the influence of these liquors upon the solvent or digestive action of pepsin-hydrochloric acid or gastric juice, and upon this question the results here recorded speak fully and clearly.

Pancreatic Digestion.

In studying the influence of alcoholic fluids upon pancreatic digestion our experiments have been limited mainly to the proteolytic action, or albumin-digesting power, of the fluid, since this may be considered as the most important digestive function of the secretion. Further, in our experiments with saliva, to be detailed later on, we have acquired all that seems necessary for us to know regarding the influence of alcoholic fluids upon the starch-digesting power of the amylolytic ferments common to both the saliva and the pancreatic fluid. So far as our knowledge at present extends, there is no difference between the saliva and pancreatic juice in their digestive action on farinaceous foods, so that what is found true with regard to the amylolytic action of the saliva is also applicable to the pancreatic fluid. Hence, in studying pancreatic digestion, our experiments have been limited to the influence of alcoholic fluids upon the tryptic ferment which is so characteristic of this secretion.

The natural secretion from the pancreatic gland has an alkaline reaction, but in the small intestine pancreatic digestion is as liable to be carried on in a neutral reacting fluid as in an alkaline medium, and as our experiments were designed mainly to show the action of the various alcoholic fluids upon the digestive power of the ferment, it seemed best to use a neutral reacting pancreatic juice. The latter was prepared, according to the method originally suggested by Kühne, from dried pancreas which had been previously extracted with alcohol and ether.[1] Forty grams of the prepared pancreas were warmed at 40° C. for twenty-four hours with 500 c.c., 0.1 per cent. salicylic acid, the solution filtered and neutralized with dilute sodium carbonate and then diluted with water to 1000 or 1500 c.c. In order to prevent the possibility of putrefactive changes, crystals of thymol were kept floating on the fluid.

In testing the digestive or proteolytic action of the pancreatic juice under the various conditions set forth, 1 gram of dry, pulverized blood-fibrin was weighed out into a suitable flask, 25 c.c. of water containing sufficient of the alcoholic liquor to give the desired percentage to the whole mixture were then added, followed by 25 c.c. of the neutral pancreatic juice, thus making a total volume of 50 c.c. for each mixture. The mixtures of each series were then placed in the same water-bath at 38°–40° C., where they were kept at the body-temperature for six to seven hours with frequent shaking,[2] the flasks being tightly stoppered. At the end of the given period the undissolved fibrin was filtered off on weighed filter-papers, washed thoroughly with warm water, and then dried at 110° C. until of constant weight. In this manner it was possible to measure very accurately the influence of various forms and quantities of alcoholic liquors upon the pancreatic digestion of proteid foods.

In view of the position which pancreatic digestion occupies in the digestive process, it is readily seen that it is more desirable to ascertain the influence of small quantities of alcoholic liquors than large amounts, since absorption must naturally lead to a decided diminution of alcohol, etc., before these fluids can normally become mixed with the pancreatic juice and partially digested food-material in the small intestine. Hence, we have laid more stress, as a rule, upon the influence of small percentages of the various fluids experimented with, and only occasionally have tried the action of large quantities.

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[1] Untersuchungen aus der physiol. Institute d. Universität Heidelberg, Band I, p. 222.

[2] Each mixture contained a trace of thymol and sodium salicylate sufficient to prevent putrefaction.

ACTION OF ABSOLUTE ALCOHOL (99.5 TO 100 PER CENT.).

Experiment 80.

Period of digestion 7 hours.

Absolute alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.[1]	0.5677 gram.	43.3 per cent.	100.0
2 “	0.6102 “	39.0 “	90.0
5 “	0.6574 “	34.3 “	79.2
10 “	0.7394 “	26.1 “	60.2
20 “	0.8446 “	15.6 “	36.0

Experiment 81.

Period of digestion 6 hours.

Absolute alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3467 gram.	65.33 per cent.	100.0
0.25 “	0.3375 “	66.25 “	101.4
0.50 “	0.3563 “	64.37 “	98 5
1.00 “	0.3599 “	64.01 “	97.9
2.00 “	0.3521 “	64.79 “	99.2
3.00 “	0.3780 “	62.20 “	95.2

Experiment 82.

Period of digestion 6 hours.

Absolute alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3058 gram.	69.42 per cent.	100.0
1 “	0 3220 “	67.80 “	97 6
3 “	0.3689 “	63.11 “	90.9
5 “	0.3888 “	61.12 “	88.0
10 “	0.5080 “	49.20 “	70.8
15 “	0.5931 “	40.69 “	58 6
20 “	0.7012 “	29.88 “	43.0

These results with absolute alcohol indicate that the proteolytic ferment of the pancreatic juice is more sensitive to absolute alcohol than the ferment of the gastric juice. Retardation of digestive action is more pronounced even with small amounts of alcohol. Further, as in the case with pepsin, the weaker the digestive powers of the pancreatic juice the greater the retarding action of absolute alcohol. This is clearly seen in comparison of Experiments 80 and 82, and is quite in harmony with what is known regarding the general nature of the digestive ferments or enzymes. When the amount of alcohol present in the digesting mixture is less than 1 per cent. the retardation of digestive action is very slight, provided the ferment is fairly vigorous in its action.

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[1] The percentages of fluid added are in every instance given by volume unless otherwise specified.

WHISKEY (WITH 50 PER CENT. OF ALCOHOL).

Experiment 83.

Period of digestion 8 hours.

Whiskey.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5147 gram.	48.6 per cent.	100.0
1 “	0.5390 “	46.1 “	94.8
3 “	0.5556 “	44.5 “	91.5
5 “	0.5635 “	43.7 “	89.9
10 “	0.5972 “	40.3 “	82.9
Absolute alcohol. 5 per cent.	0.5621 “	43.8 “	90.1

Experiment 84.

Period of digestion 7¼ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3272 gram.	67.3 per cent.	100.0
10 “ whiskey	0.4002 “	60.0 “	89.1
10 “ “ distil.	0.3860 “	61.4 “	91.2
10 “ “ residue	0.3360 “	66.4 “	98.6
5 “ absol. alcohol	0.3858 “	61.5 “	91.3

From these results it is plain that even small amounts of whiskey are detrimental to the digestive action of pancreatic juice on proteid foods. The sensitiveness of the enzyme to this form of alcoholic liquor is quite marked. Further, it is to be noticed that, as with alcohol, the weaker the digestive fluid the stronger is the retarding action of the whiskey. It is also seen that the inhibition produced by a given percentage of whiskey is somewhat greater than that caused by a corresponding percentage of alcohol, thus indicating that there must be some other retarding agent aside from the alcohol present in the whiskey. The general character of this substance is apparent when we compare the action of the distillate and the residue from a given volume of whiskey with that of the whiskey itself.

Thus, the distillate, *i. e.*, the volatile matter of the whiskey, causes less retardation of digestive action than the whiskey itself, although its action is exactly equal to that of a corresponding strength of absolute alcohol. Hence, the difference in action must be attributed to the character of the solid matter present in the liquor, even though the amount present is small.[1] The experiment, indeed, shows that the residue has a sufficient inhibitory action upon tryptic digestion to account fully for the difference in action between whiskey and a corresponding strength of alcohol. As the whiskey residue is decidedly acid in reaction, and the tryptic ferment is well known to be sensitive to the presence of acids, it is reasonable to assume that it is the presence of the latter which is the cause in part, at least, of the greater inhibitory action of the whiskey over that of corresponding strengths of alcohol.

Influence of So-called Fusel Oils on the Proteolytic Action of Pancreatic Juice.

As already described under the head of gastric digestion, whiskey, brandy, and other distilled liquors of this class are supposedly liable to contamination with so-called fusel oils, of which the higher alcohols are the chief constituents.

We have therefore studied the influence of a number of representative alcohols of this type upon trypsin-proteolysis with a view to ascertaining what effect their possible presence in whiskeys and other like liquors might have upon the rate of pancreatic digestion.[2]

Amyl Alcohol.

Experiment 85.

Period of digestion 6 hours.

Amyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4090 gram.	59.1 per cent.	100.0
0.05 "	0.4113 "	58.8 "	99.6
0.10 "	0.4117 "	58.8 "	99 5
0.25 "	0.4149 "	58.5 "	99.0
0.50 "	0.4200 "	58.0 "	98.1
1 00 "	0.4740 "	52.6 "	89.0
2.00 "	0.5140 "	48.6 "	82.2

Experiment 86.

Period of digestion 6 hours.

Amyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3107 gram.	68.9 per cent.	100.0
0.05 "	0.3153 "	68.4 "	99.1
0.10 "	0.3442 "	65.5 "	95.1
0.25 "	0.3350 "	66.5 "	96.4
0.50 "	0.3462 "	65.3 "	94.8
1.00 "	0.4027 "	59.7 "	86.6
2.00 "	0.4598 "	54.0 "	78.3

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[1] The whiskey contained about 0.3 per cent. of solid matter.

[2] These experiments were carried out in our laboratory by Edward E. Brownell, Ph.B.

ISOBUTYL ALCOHOL.

Experiment 87.

Period of digestion 6 hours.

Isobutyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4185 gram.	58.1 per cent.	100.0
0.05 "	0.4282 "	57.1 "	98.3
0.10 "	0.4305 "	56.9 "	97.9
0.25 "	0.4360 "	56.4 "	97.0
0.50 "	0.4478 "	55.2 "	94.9
1.00 "	0.4491 "	55.0 "	94.7
2.00 "	0.4827 "	47.5 "	81.7

Experiment 88.

Period of digestion 6 hours.

Isobutyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3776 gram.	62.2 per cent.	100.0
0.05 "	0.3796 "	62.0 "	99.7
0.10 "	0.3890 "	61.1 "	98.1
0.25 "	0.3864 "	61.3 "	98.5
0.50 "	0.4116 "	58.8 "	94.5
1.00 "	0.4230 "	57.7 "	92.7
2.00 "	0.4561 "	54.3 "	81.5

Experiment 89.

Period of digestion 6 hours.

Isobutyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2980 gram.	70.2 per cent.	100.0
1 "	0.3334 "	66.6 "	94.9
3 "	0.4052 "	59.4 "	84.7
5 "	0.5431 "	45.6 "	65.0
10 "	0.7333 "	26.6 "	37.9
15 "	0.7743 "	22.5 "	32.1
20 "	0.7813 "	21.8 "	31.1

PROPYL ALCOHOL.

Experiment 90.

Period of digestion 6 hours.

Propyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4096 gram.	59.0 per cent.	100.0
0.05 "	0.4088 "	59.1 "	100.1
0.10 "	0.4081 "	59.2 "	100.2
0.25 "	0.4100 "	59.0 "	99.9
0.50 "	0.4159 "	58.4 "	98.7
1.00 "	0.4333 "	56.6 "	95.9
2.00 "	0.4336 "	56.6 "	95.9

Experiment 91.

Period of digestion 6 hours.

Propyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3920 gram.	60.8 per cent.	100.0
0.05 "	0.3702 "	62.9 "	103.6
0.10 "	0.3875 "	61.2 "	100.7
0.25 "	0.3946 "	60.5 "	99.5
0.50 "	0.4030 "	59.7 "	98.2
1.00 "	0.4082 "	59.1 "	97.3
2.00 "	0.4210 "	57.9 "	95.2

Experiment 92.

Period of digestion 6 hours.

Propyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3486 gram.	65.1 per cent.	100.0
1 "	0.3420 "	65.8 "	101.0
3 "	0.3900 "	61.0 "	93.6
5 "	0.4456 "	55.4 "	85.1
10 "	0.6032 "	39.6 "	60.9
15 "	0.7850 "	21.5 "	33.0
20 "	0.9255 "	7.4 "	11 4

METHYL ALCOHOL.

Experiment 93.

Period of digestion 6 hours.

Methyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3850 gram.	61.5 per cent.	100.0
0.25 "	0.3832 "	61.8 "	100.3
0.50 "	0.3931 "	60.7 "	98.7
1.00 "	0.3813 "	61.8 "	100.6
2.00 "	0.3812 "	61.8 "	100.6
3.00 "	0.3862 "	61.3 "	99.7

Experiment 94.

Period of digestion 6 hours.

Methyl alcohol.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3423 gram.	65.7 per cent.	100.0
1 "	0.3702 "	62.9 "	95 7
3 "	0.4143 "	58.5 "	89.2
5 "	0.4237 "	57.6 "	87.7
10 "	0.5253 "	47.4 "	72.3
15 "	0 6195 "	38.0 "	56.3
20 "	0.7170 "	28.3 "	43.0

The following experiment was designed to show the *comparative* action of methyl, ethyl, propyl, and isobutyl alcohols upon trypsin-proteolysis. The period of digestion was six hours at 38–40°.

Experiment 95.

Alcohol added.		Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.		0.3117 gram.	68.8 per cent.	100.0
5 "	methyl	0.3968 "	60.3 "	87.6
5 "	ethyl	0.4081 "	59.2 "	86.0
5 "	propyl	0.4620 "	53.8 "	78.1
5 "	isobutyl	0.5183 "	48.2 "	70.0
15 "	methyl	0.5926 "	40.7 "	59.1
15 "	ethyl	0.6213 "	37.8 "	54.9
15 "	propyl	0.8155 "	18.4 "	26.7
15 "	isobutyl	0.8024 "	19.7 "	28.6

A careful scrutiny of all of the foregoing results obtained with the alcohols liable to be present in so-called fusel oils, shows that their inhibitory action upon trypsin-proteolysis is somewhat greater than that of ordinary ethyl alcohol. When it is considered, however, that they can at the most be present in whiskeys, brandies, and the like only in very small quantities, it is apparent that their retarding action can have little practical influence in modifying ordinary proteolytic action. Physiologically, however, the results obtained in Experiment 95 are extremely interesting, since they tend to show that the retarding action of these alcohols on trypsin-proteolysis increases with the weight of the alcohol. Thus, in digestive mixtures containing 5 per cent. of these alcohols the lowest member of the series, methyl alcohol, has the least inhibitory action, while isobutyl alcohol, the highest alcohol tested, has the greatest retarding effect. If these alcohols were present in any quantity in alcoholic liquors, their retarding action on trypsin-proteolysis would unquestionably be a very important factor; but as there is no evidence that they are ever present in more than traces their action in this direction can have little practical importance.

BRANDY (WITH 48 PER CENT. OF ALCOHOL).

Experiment 96.

Period of digestion $7\frac{5}{12}$ hours.

Brandy.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5531 gram.	44.7 per cent.	100.0
1 "	0.5701 "	43.0 "	96.1
3 "	0.5808 "	42.0 "	93.9
5 "	0.5812 "	41.9 "	93.7
10 "	0.6131 "	38.7 "	86.5
Absolute alcohol.			
5 per cent.	0.6135 "	38.7 "	86.5

Experiment 97.

Period of digestion 8 hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2974 gram.	72.1 per cent.	100.0
10 " brandy	0.3522 "	64.8 "	89.8
10 " " distil.	0.3635 "	63.7 "	88.3
10 " " residue	0.3083 "	69.2 "	95.9
5 " absol. alcohol	0.3475 "	65.3 "	90.5

Here we have much the same results as were obtained with whiskey. Thus, retardation of proteolysis is quite pronounced with 10 per cent. of brandy, but with 1 per cent. it is comparatively slight. Unlike whiskey, however, the action of the brandy is due almost entirely to the alcohol it contains, although the solid matter present in it has some retarding action.

Rum (with 51 Per Cent. of Alcohol).

Experiment 98.

Period of digestion 7⅝ hours.

Rum.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5611 gram.	43.9 per cent.	100.0
1 "	0.5805 "	42.0 "	95.6
3 "	0.6077 "	39.3 "	89.5
5 "	0.6230 "	37.7 "	85.8
10 "	0.6661 "	33.4 "	76.0
Alsolute alcohol.			
5 per cent.	0.6339 "	36.7 "	83.5

Experiment 99.

Period of digestion 8 hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.2794 gram.	72.1 per cent.	100.0
10 " rum	0.3620 "	63.8 "	88.0
10 " " distillate	0.3562 "	64.4 "	89.3
10 " " residue	0.2974 "	70.3 "	97.5
5 " absol. alcohol	0.3475 "	65.3 "	90.5

With rum, retardation of proteolysis is quite pronounced in the presence of even 5 per cent. of the liquor, although, as in other cases, the exact amount of retardation is dependent largely upon the strength or activity of the pancreatic juice. Further, while the retarding action is due mainly to the contained alcohol, yet it is evident that the solid matter of the rum has a somewhat deleterious influence, the two factors combining to cause the slow digestive action of mixtures containing 5 and 10 per cent. of rum.

If one should attempt a comparison of the action of these strong alcoholic liquors upon pepsin-proteolysis and trypsin-proteolysis, the conclusion, we think, would be that pepsin-hydrochloric acid is far less sensitive to the action of these alcoholic fluids than trypsin. The latter is far more liable to be retarded in its digestive activity than pepsin by small amounts of these fluids. Further, in trypsin-proteolysis there is not quite so close a relationship between the extent of retardation and the content of alcohol in the fluid under examination. In other words, the tryptic ferment is not only more sensitive to the action of alcohol, but it is likewise more inclined to be affected by the various extractives, especially the acid-reacting bodies, present in these liquors than is the case with pepsin.

SHERRY (WITH 21 PER CENT. OF ALCOHOL AND 4.7 PER CENT. OF SOLID MATTER).

Experiment 100.

Period of digestion 8½ hours.

Sherry.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5246 gram.	47.6 per cent.	100.0
1 "	0.5473 "	45.3 "	95.1
3 "	0.5803 "	42.0 "	88.2
5 "	0.6200 "	38.0 "	79.8
10 "	0.7128 "	28.8 "	60.5
Absolute alcohol.			
2 per cent.	0.5776 "	42.3 "	88.8

Experiment 101.

Period of digestion 7¼ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3272 gram.	67.3 per cent.	100.0
10 " sherry	0.4452 "	55.5 "	82.4
10 " " distil.	0.3678 "	63.3 "	94.0
10 " " residue	0.4082 "	59.2 "	87.9
5 " absol. alcohol	0.3858 "	61.5 "	91.3

CLARET (WITH 10 PER CENT. OF ALCOHOL AND 3.3 PER CENT. OF SOLID MATTER).

Experiment 102.

Period of digestion 7½ hours.

Claret.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5799 gram.	42.1 per cent.	100.0
1 "	0.5966 "	40.4 "	95.9
3 "	0.6475 "	35.3 "	86.2
5 "	0.6963 "	30.4 "	72.2
10 "	0.8539 "	14.7 "	34.9
Absolute alcohol.			
2 per cent.	0.6020 "	39.8 "	94.5

Experiment 103.

Period of digestion 6 hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3604 gram.	64.0 per cent.	100.0
10 " claret	0.5842 "	41.6 "	65.0
10 " " distil.	0.3963 "	60.4 "	94.3
10 " " residue	0.5403 "	46.0 "	71 8
1 " absol. alcohol	0.3973 "	60.3 "	94.2

HOCHHEIMER (WITH 11 PER CENT. OF ALCOHOL AND 1.8 PER CENT. OF SOLID MATTER).

Experiment 104.

Period of digestion 8½ hours.

Hochheimer.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5325 gram.	46 8 per cent.	100.0
3 "	0.5991 "	40.1 "	85.6
5 "	0.6357 "	36.5 "	77.9
10 "	0.7564 "	24.4 "	52.1
Absolute alcohol.			
1 per cent.	0.5785 "	42 2 "	90.1

Experiment 105.

Period of digestion 6 hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3604 gram.	64.0 per cent.	100.0
10 " hochheimer	0.5267 "	47.4 "	74.0
10 " " distil.	0.3993 "	60.1 "	93.9
10 " " residue	0.4760 "	52.4 "	81.8
1 " absol. alcohol	0.3973 "	60.3 "	94.2

Comparative Action of Strong Liquors and Wines.

Experiment 106.

Period of digestion 7¼ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5945 gram.	40.6 per cent.	100.0
5 " absol. alcohol	0.6622 "	33.8 "	83.2
10 " whiskey	0.6844 "	31.6 "	77.8
10 " brandy	0.6465 "	35.4 "	87.1[1]
10 " rum	0.6818 "	31.9 "	78.5
10 " sherry	0.7506 "	25.0 "	61.5
10 " hochheimer	0.7850 "	21.5 "	52.9
10 " claret	0.8533 "	14.7 "	36 2

Considering now the import of the results obtained by our study of the action of these wines upon trypsin-proteolysis, it is evident that these fluids have a far greater inhibitory action than the stronger liquors, such as whiskey, brandy, etc. Further, it is plain that the action of any given wine upon the tryptic digestion of proteid foods is quite independent of its content of alcohol. Retardation of digestive action is out of all proportion to the alcohol present in the fluid. Contrast, for example, the action of claret, with the smallest percentage of alcohol, with that of sherry, which contains double the amount of alcohol. Further, between claret and the white wine (hochheimer) there is a wide difference in inhibitory action, although the difference in the content of alcohol amounts to only 1 per cent. The alcohol present in these wines plainly exerts a retarding influence upon proteolysis, as is apparent from the results obtained with the distillates from the respective fluids, and in this connection it is to be noted that the retardation produced by the distillates from both claret and hochheimer is essentially the same, and, moreover, is practically identical with the retardation caused by a corresponding percentage of absolute alcohol.

The greater part of the retardation produced by these wines, however, is clearly connected with the character of the solid matter present in the fluids. Thus, it is to be noted that there is no close relationship, at least, between the amount of solid matter in the wine and its inhibitory action. We therefore sought for some explanation of the above results in the specific character of this solid or non-volatile matter, and our conclusion is that the retardation is due in great part to the amount of acid contained in the respective fluids; a conclusion which will apply not only to the wine-residues, but likewise to the solid matter contained in the stronger alcoholic fluids.

[1] This result is presumably too high, although we know of no cause of error.

The acidity of these fluids was determined by neutralization of a given volume with a standard solution of potassium hydroxide, containing 0.2 per cent. KOH. The relative acidity is indicated by the following figures which show the number of cubic centimetres of the alkali solution required to neutralize 25 c.c. of the respective liquors:

25 c.c. brandy . . .	required	3 0	c.c.	alkali solution.
25 " whiskey . . .	"	3.5	"	"
25 " rum . . .	"	15.0	"	"
25 " sherry . . .	"	58.5	"	"
25 " hochheimer . . .	"	80.3	"	"
25 " claret . . .	"	87.0	"	"

Trypsin, the proteolytic ferment of the pancreatic juice, is well known to be extremely sensitive to the presence of acids, and when this fact is remembered we have, perhaps, in the above data, a full explanation of the marked retardation of trypsin-proteolysis caused by the above acid wines; a retardation far greater than that caused by the alcohol contained in them. Further, the inhibitory action on tryptic digestion produced by the solid matter present in whiskey, brandy, and rum is likewise to be assigned, in part at least, to this same cause. In addition to this possible explanation it must also be remembered that many neutral salts, such as are liable to be present in these liquors, likewise have an inhibitory action on proteolytic enzymes.

(To be continued.)

A CASE OF ACUTE LEAD-ENCEPHALOPATHY WITH INTERESTING OCULAR MANIFESTATIONS.

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L. H., female, a carpet-weaver, aged twenty-two years, was sent to the Episcopal Hospital on January 31, 1894, by Drs. Francis N. Bennett and G. Oram Ring, who had recognized the conditions about to be described, attributing them to intracranial disease.

At the hospital the following history was elicited: The patient's parents were healthy. At the age of ten she had typhoid fever, and since then diphtheria, pleurisy, and malaria. One year ago she was again attacked by malaria, and had not been strong since.

In the early part of August, 1894, she began to have headaches, loss of appetite, vertigo, and dimness of vision. These symptoms increased